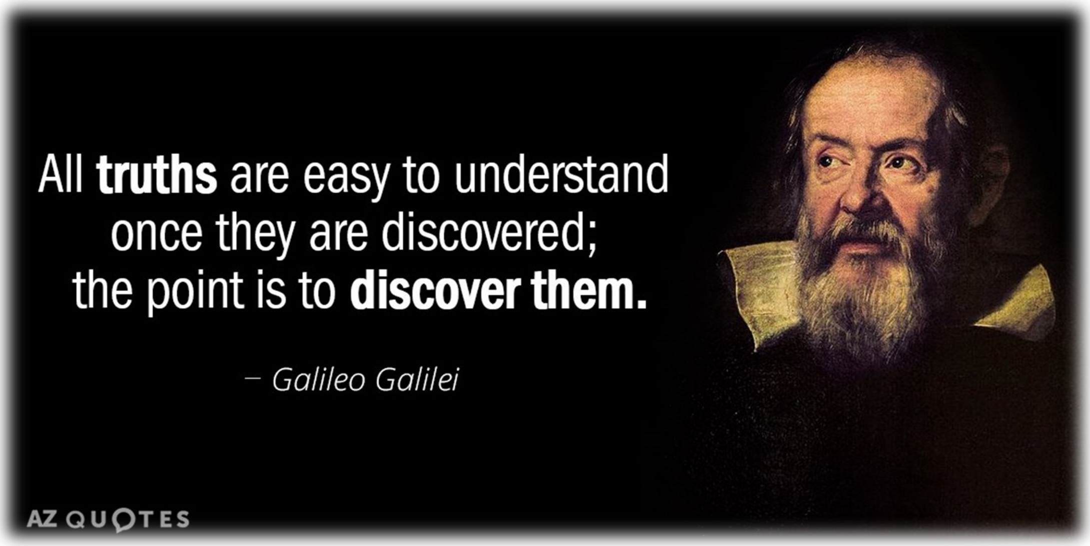
108
Greatest Of All Times

GOAT

Globally selected Personalities



15 Feb 1564 <::><::><::> 8 Jan 1642

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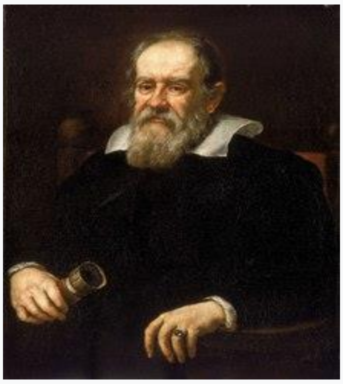
https://en.wikipedia.org/wiki/Galileo_Galilei

Galileo Galilei



Portrait c. 1640

Born	Galileo di Vincenzo Bonaiuti de' Galilei 15 February 1564 Pisa, Duchy of Florence
Died	8 January 1642 (aged 77) Arcetri, Grand Duchy of Tuscany
Education	University of Pisa
Known for	show **List**
Scientific career	
Fields	• Astronomy • physics • engineering • natural philosophy • mathematics
Institutions	• University of Pisa • University of Padua
Patrons	• Cosimo II de Medici • Federico Cesi • Ferdinando II de Medici • Fra Paolo Sarpi

	• Francesco Maria del Monte
Academic advisors	Ostilio Ricci da Fermo
Notable students	• Benedetto Castelli • Mario Guiducci • Vincenzo Viviani

Signature

Galileo di Vincenzo Bonaiuti de' Galilei (15 February 1564 – 8 January 1642), commonly referred to as **Galileo Galilei** (/ˌɡælɪˈleɪoʊ ˌɡælɪˈleɪ/, US also /ˌɡælɪˈliːoʊ -/; Italian: [ɡaliˈlɛːo ɡaliˈlɛːi]) or mononymously as **Galileo**, was an Italian (Florentine) astronomer, physicist and engineer, sometimes described as a polymath. He was born in the city of Pisa, then part of the Duchy of Florence and present-day Italy. Galileo has been called the father of observational astronomy, modern-era classical physics, the scientific method, and modern science.

Galileo studied speed and velocity, gravity and free fall, the principle of relativity, inertia, projectile motion and also worked in applied science and technology, describing the properties of the pendulum and "hydrostatic balances". He was one of the earliest Renaissance developers of the thermoscope and the inventor of various military compasses. With an improved telescope he built, he observed the stars of the Milky Way, the phases of Venus, the four largest satellites of Jupiter, Saturn's rings, lunar craters and sunspots. He also built an early microscope.

Galileo's championing of Copernican heliocentrism was met with opposition from within the Catholic Church and from some astronomers. The matter was investigated by the Roman Inquisition in 1615, which concluded that his opinions contradicted accepted Biblical interpretations.

Galileo later defended his views in *Dialogue Concerning the Two Chief World Systems* (1632), which appeared to attack Pope Urban VIII and thus alienated both the Pope and the Jesuits, who had

both supported Galileo up until this point. He was tried by the Inquisition, found "vehemently suspect of heresy", and forced to recant. He spent the rest of his life under house arrest. During this time, he wrote *Two New Sciences* (1638), primarily concerning kinematics and the strength of materials.

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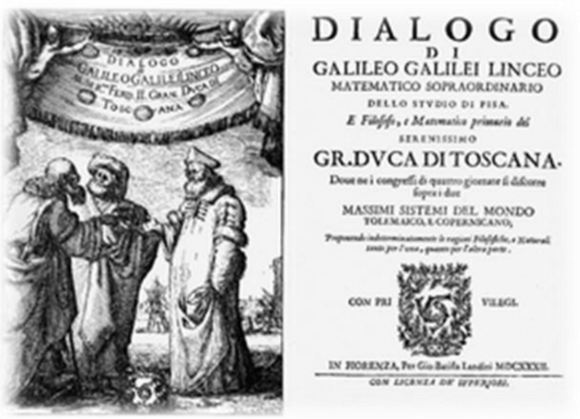
Dialogue Concerning the Two Chief World Systems

https://en.wikipedia.org/wiki/Dialogue_Concerning_the_Two_Chief_World_Systems

The ***Dialogue Concerning the Two Chief World Systems*** (*Dialogo sopra i due massimi sistemi del mondo*) is a 1632 Italian-language book by Galileo Galilei comparing the Copernican system with the traditional Ptolemaic system. It was translated into Latin as *Systema cosmicum* (*Cosmic System*) in 1635 by Matthias Bernegger. The book was dedicated to Galileo's patron, Ferdinando II de' Medici, Grand Duke of Tuscany, who received the first printed copy on February 22, 1632.

In the Copernican system, the Earth and other planets orbit the Sun, while in the Ptolemaic system, everything in the Universe circles around the Earth. The *Dialogue* was published in Florence under a formal license from the Inquisition. In 1633, Galileo was found to be "vehemently suspect of heresy" based on the book, which was then placed on the *Index of Forbidden Books*, from which it was not removed until 1835 (after the theories it discussed had been permitted in print in 1822). In an action that was not announced at the time, the publication of anything else he had written or ever might write was also banned in Catholic countries.



Frontispiece and title page of the *Dialogue*, 1632.

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Two New Sciences

https://en.wikipedia.org/wiki/Two_New_Sciences

Discourses and Mathematical Demonstrations Relating to Two New Sciences

Author	Galileo Galilei
Language	Italian, Latin
Published	1638

The ***Discourses and Mathematical Demonstrations Relating to Two New Sciences*** (Italian: *Discorsi e dimostrazioni matematiche intorno a due nuove scienze* pronounced [diˈskorsi e ddimostratˈtsjoːni mateˈmaːtike inˈtorno a dˈduːe ˈnwɔːve ʃˈʃɛntse]) published in 1638 was Galileo Galilei's final book and a scientific testament covering much of his work in physics over the preceding thirty years. It was written partly in Italian and partly in Latin.

After his *Dialogue Concerning the Two Chief World Systems*, the Roman Inquisition had banned the publication of any of Galileo's works, including any he might write in the future. After the failure of his initial attempts to publish *Two New Sciences* in France, Germany, and Poland, it was published by Lodewijk Elzevir who was working in Leiden, South Holland, where the writ of the Inquisition was of less consequence (see House of Elzevir). Fra Fulgenzio Micanzio, the official theologian of the Republic of Venice, had initially offered to help Galileo publish the new work there, but he pointed out that publishing the *Two New Sciences* in Venice might cause Galileo unnecessary trouble; thus, the book was eventually published in Holland. Galileo did not seem to suffer any harm from the Inquisition for publishing this book since in January 1639, the book reached Rome's bookstores, and all available copies (about fifty) were quickly sold.

Discourses was written in a style similar to *Dialogues*, in which three men (Simplicio, Sagredo, and Salviati) discuss and debate the various questions Galileo is seeking to answer. There is a notable change in the men, however; Simplicio, in particular, is no longer quite as simple-minded, stubborn and Aristotelian as his name implies. His arguments are representative of Galileo's own early beliefs, as Sagredo represents his middle period, and Salviati proposes Galileo's newest models.

Introduction

The book is divided into four days, each addressing different areas of physics. Galileo dedicates *Two New Sciences* to Lord Count of Noailles.

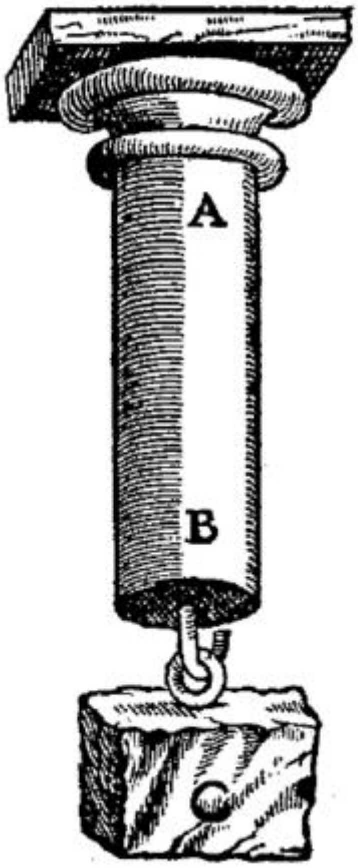


Figure 1 out of Galileo's *Two New Sciences* in the First Day section

In the First Day, Galileo addressed topics that were discussed in Aristotle's Physics and also the Aristotelian school Mechanics. It also provides an introduction to the discussion of both of the new sciences. The likeness between the topics discussed, specific questions that are hypothesized, and the style and sources throughout give Galileo the backbone to his First Day. The First Day introduces the speakers in the dialogue: Salviati, Sagredo, and Simplicio, the same as in the Dialogue. These three people are all Galileo just at different stages of his life, Simplicio the youngest and Salviati, Galileo's closest counterpart. The Second Day addresses the question of the strength of materials.

The Third and Fourth days address the science of motion. The Third day discusses uniform and naturally accelerated motion, the issue of terminal velocity having been addressed in the First day. The Fourth day discusses projectile motion.

In *Two Sciences* uniform motion is defined as a motion that, over *any* equal periods of time, covers equal distance. With the use of the quantifier ″any″, uniformity is introduced and expressed more explicitly than in previous definitions.

Galileo had started an additional day on the force of percussion, but was not able to complete it to his own satisfaction. This section was referenced frequently in the first four days of discussion. It finally appeared only in the 1718 edition of Galilei's works. and it is often quoted as "Sixth Day" following the numbering in the 1898 edition. During this additional day Simplicio was replaced by Aproino, a former scholar and assistant of Galileo in Padua.

Summary

Page numbers at the start of each paragraph are from the 1898 version,[7] presently adopted as standard, and are found in the Crew and Drake translations.

Day one: Resistance of bodies to separation

[50] **Preliminary discussions.** Sagredo (taken to be the younger Galileo) cannot understand why with machines one cannot argue from the small to the large: "I do not see that the properties of circles, triangles and...solid figures should change with their size". Salviati (speaking for Galileo) says the common opinion is wrong. Scale matters: a horse falling from a height of 3 or 4 cubits will break its bones whereas a cat falling from twice the height won't, nor will a grasshopper falling from a tower.

[56] The first example is a hemp rope which is constructed from small fibres which bind together in the same way as a rope round a windlass to produce something much stronger. Then the vacuum that prevents two highly polished plates from separating even though they slide easily gives rise to an experiment to test whether water can be expanded or whether a vacuum is caused. In fact, Sagredo had observed that a suction pump could not lift more than 18 cubits of water and Salviati observes that the weight of this is the amount of resistance to a void. The discussion turns to the strength of a copper wire and whether there are minute void spaces inside the metal or whether there is some other explanation for its strength.

[68] This leads into a discussion of infinites and the continuum and thence to the observation that the number of squares equal the number of roots. He comes eventually to the view that "if any number can be said to be infinite, it must be unity" and demonstrates a construction in which an infinite circle is approached and another to divide a line.

[85] The difference between a fine dust and a liquid leads to a discussion of light and how the concentrated power of the sun can melt metals. He deduces that light has motion and describes an (unsuccessful) attempt to measure its speed.

[106] Aristotle believed that bodies fell at a speed proportional to weight but Salviati doubts that Aristotle ever tested this. He also did not believe that motion in a void was possible, but since air is much less dense than water Salviati asserts that in a medium

devoid of resistance (a vacuum) all bodies—a lock of wool or a bit of lead—would fall at the same speed. Large and small bodies fall at the same speed through air or water providing they are of the same density. Since ebony weighs a thousand times as much as air (which he had measured), it will fall only a very little more slowly than lead which weighs ten times as much. But shape also matters—even a piece of gold leaf (the densest of all substances [asserts Salviati]) floats through the air and a bladder filled with air falls much more slowly than lead.

[128] Measuring the speed of a fall is difficult because of the small time intervals involved and his first way round this used pendulums of the same length but with lead or cork weights. The period of oscillation was the same, even when the cork was swung more widely to compensate for the fact that it soon stopped.

[139] This leads to a discussion of the vibration of strings and he suggests that not only the length of the string is important for pitch but also the tension and the weight of the string.

Day two: Cause of cohesion

[151] Salviati proves that a balance can not only be used with equal arms but with unequal arms with weights inversely proportional to the distances from the fulcrum. Following this he shows that the moment of a weight suspended by a beam supported at one end is proportional to the square of the length. The resistance to fracture of beams of various sizes and thicknesses is demonstrated, supported at one or both ends.

[169] He shows that animal bones have to be proportionately larger for larger animals and the length of a cylinder that will break under its own weight. He proves that the best place to break a stick placed upon the knee is the middle and shows how far along a beam that a larger weight can be placed without breaking it.

[178] He proves that the optimum shape for a beam supported at one end and bearing a load at the other is parabolic. He also shows that hollow cylinders are stronger than solid ones of the same weight.

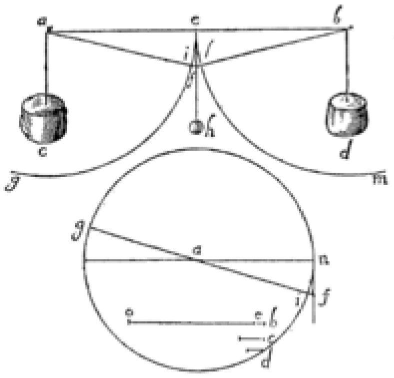
Day three: Naturally accelerated motion

[191] He first defines uniform (steady) motion and shows the relationship between speed, time and distance. He then defines uniformly accelerated motion where the speed increases by the same amount in increments of time. Falling bodies start very slowly and he sets out to show that their velocity increases in simple proportionality to time, not to distance which he shows is impossible.

[208] He shows that the distance travelled in naturally accelerated motion is proportional to the square of the time. He describes an experiment in which a steel ball was rolled down a groove in a piece of wooden moulding 12 cubits long (about 5.5m) with one end raised by one or two cubits. This was repeated, measuring times by accurately weighing the amount of water that came out of a thin pipe in a jet from the bottom of a large jug of water. By this means he was able to verify the uniformly accelerated motion. He then shows that whatever the inclination of the plane, the square of the time taken to fall a given vertical height is proportional to the inclined distance.

[221] He next considers descent along the chords of a circle, showing that the time is the same as that falling from the vertex, and various other combinations of planes. He gives an erroneous solution to the brachistochrone problem, claiming to prove that the arc of the circle is the fastest descent. 16 problems with solutions are given.

Day four: The motion of projectiles



Last figure of the Fourth Day of Galileo's *Two New Sciences*

[268] The motion of projectiles consists of a combination of uniform horizontal motion and a naturally accelerated vertical motion which produces a parabolic curve. Two motions at right angles can be calculated using the sum of the squares. He shows in detail how to construct the parabolas in various situations and gives tables for altitude and range depending on the projected angle.

[274] Air resistance shows itself in two ways: by affecting less dense bodies more and by offering greater resistance to faster bodies. A lead ball will fall slightly faster than an oak ball, but the difference with a stone ball is negligible. However, the speed does not go on increasing indefinitely but reaches a maximum. Though at small speeds the effect of air resistance is small, it is greater when considering, say, a ball fired from a cannon.

[292] The effect of a projectile hitting a target is reduced if the target is free to move. The velocity of a moving body can overcome that of a larger body if its speed is proportionately greater than the resistance.

[310] A cord or chain stretched out is never level but also approximates to a parabola. (But see also catenary.)

Additional day: The force of percussion

[323] What is the weight of water falling from a bucket hanging on a balance arm onto another bucket suspended to the same arm?

[325] Piling of wooden poles for foundations; hammers and the force of percussion.

[336] Speed of fall along inclined planes; again, on the principle of inertia.

Methodology

Many contemporary scientists, such as Gassendi, dispute Galileo's methodology for conceptualizing his law of falling bodies. Two of the main arguments are that his epistemology followed the example of Platonist thought or hypothetico-deductivist. It

has now been considered to be *ex suppositione*, or knowing the how and why effects from past events in order to determine the requirements for the production of similar effects in the future. Galilean methodology mirrored that of Aristotelian and Archimedean epistemology. Following a letter from Cardinal Bellarmine in 1615 Galileo distinguished his arguments and Copernicus' as natural suppositions as opposed to the "fictive" that are "introduced only for the sake of astronomical computations," such as Ptolemy's hypothesis on eccentrics and equants.

Galileo's earlier writing considered Juvenilia, or youthful writings, are considered his first attempts at creating lecture notes for his course "hypothesis of the celestial motions" while teaching in at the University of Padua. These notes mirrored those of his contemporaries at the Collegio as well as contained an "Aristotelian context with decided Thomistic (St. Thomas Aquinas) overtones." These earlier papers are believed to have encouraged him to apply demonstrative proof in order to give validity to his discoveries on motion.

Discovery of folio 116v gives evidence of experiments that had previously not been reported and therefore demonstrated Galileo's actual calculations for the Law of Falling Bodies.

His methods of experimentation have been proved by the recording and recreation done by scientists such as James MacLachlan, Stillman Drake, R.H. Taylor and others in order to prove he did not merely imagine his ideas as historian Alexandre Koyré argued, but sought to prove them mathematically.

Galileo believed that knowledge could be acquired through reason, and reinforced through observation and experimentation. Thus, it can be argued that Galileo was a rationalist, and also that he was an empiricist.

The two new sciences

The two sciences mentioned in the title are the strength of materials and the motion of objects (the forebears of modern material engineering and kinematics).[10] In the title of the book "mechanics" and "motion" are separate, since at Galileo's time "mechanics" meant only statics and strength of materials.

The science of materials

The discussion begins with a demonstration of the reasons that a large structure proportioned in exactly the same way as a smaller one must necessarily be weaker known as the square–cube law. Later in the discussion this principle is applied to the thickness required of the bones of a large animal, possibly the first quantitative result in biology, anticipating J. B. S. Haldane's work *On Being the Right Size, and other essays,* edited by John Maynard Smith.

The motion of objects

Galileo expresses clearly for the first time the constant acceleration of a falling body which he was able to measure accurately by slowing it down using an inclined plane.

In *Two New Sciences*, Galileo (Salviati speaks for him) used a wood molding, "12 cubits long, half a cubit wide and three finger-breadths thick" as a ramp with a straight, smooth, polished groove to study rolling balls ("a hard, smooth and very round bronze

ball"). He lined the groove with "parchment, also smooth and polished as possible". He inclined the ramp at various angles, effectively slowing down the acceleration enough so that he could measure the elapsed time. He would let the ball roll a known distance down the ramp, and use a water clock to measure the time taken to move the known distance. This clock was

a large vessel of water placed in an elevated position; to the bottom of this vessel was soldered a pipe of small diameter giving a thin jet of water, which we collected in a small glass during the time of each descent, whether for the whole length of the channel or for a part of its length. The water collected was weighed, and after each descent on a very accurate balance, the differences and ratios of these weights gave him the differences and ratios of the times. This was done with such accuracy that although the operation was repeated many, many times, there was no appreciable discrepancy in the results.

The law of falling bodies

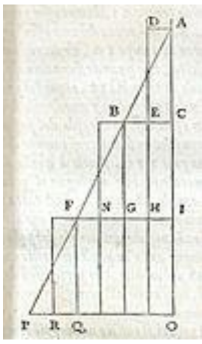
While Aristotle had observed that heavier objects fall more quickly than lighter ones, in *Two New Sciences* Galileo postulated that this was due *not* to inherently stronger forces acting on the heavier objects, but to the countervailing forces of air resistance and friction. To compensate, he conducted experiments using a shallowly inclined ramp, smoothed so as to eliminate as much friction as possible, on which he rolled down balls of different weights. In this manner, he was able to provide empirical evidence that matter accelerates vertically downward at a constant rate, regardless of mass, due to the effects of gravity.

The unreported experiment found in folio 116V tested the constant rate of acceleration in falling bodies due to gravity. This experiment consisted of dropping a ball from specified heights onto a deflector in order to transfer its motion from vertical to horizontal. The data from the inclined plane experiments were used to calculate the expected horizontal motion. However, discrepancies were found in the results of the experiment: the observed horizontal distances disagreed with the calculated distances expected for a constant rate of acceleration. Galileo attributed the discrepancies to air resistance in the unreported experiment, and friction in the inclined plane experiment. These discrepancies forced Galileo to assert that the postulate held only under "ideal conditions," i.e., in the absence of friction and/or air resistance.

Bodies in motion

Aristotelian physics argued that the Earth must not move as humans are unable to perceive the effects of this motion. A popular justification of this is the experiment of an archer shooting an arrow straight up into the air. If the Earth were moving, Aristotle argued, the arrow should fall in a different location than the launch point. Galileo refuted this argument in *Dialogues Concerning the Two Chief World Systems*. He provided the example of sailors aboard a boat at sea. The boat is obviously in motion, but the sailors are unable to perceive this motion. If a sailor were to drop a weighted object from the mast, this object would fall at the base of the mast rather than behind it (due to the ship's forward motion). This was the result of simultaneously the horizontal and vertical motion of the ship, sailors, and ball.

Relativity of motions



Picture in Galileo's *Discorsi* (1638) illustrating relativity of motions

One of Galileo's experiments regarding falling bodies was that describing the relativity of motions, explaining that, under the right circumstances, "one motion may be superimposed upon another without effect upon either...". In *Two New Sciences*, Galileo made his case for this argument and it would become the basis of Newton's first law, the law of inertia.

He poses the question of what happens to a ball dropped from the mast of a sailing ship or an arrow fired into the air on the deck. According to Aristotle's physics, the ball dropped should land at the stern of the ship as it falls straight down from the point of origin. Likewise the arrow when fired straight up should not land in the same spot if the ship is in motion. Galileo offers that there are two independent motions at play. One is the accelerating vertical motion caused by gravity while the other is the uniform horizontal motion caused by the moving ship which continues to influence the trajectory of the ball through the principle of inertia. The combination of these two motions results in a parabolic curve. The observer cannot identify this parabolic curve because the ball and observer share the horizontal movement imparted to them by the ship, meaning only the perpendicular, vertical motion is perceivable. Surprisingly, nobody had tested this theory with the simple experiments needed to gain a conclusive result until Pierre Gassendi published the results of said experiments in his letters entitled *De Motu Impresso a Motore Translato* (1642).

Infinity

The book also contains a discussion of infinity. Galileo considers the example of numbers and their squares. He starts by noting that:

It cannot be denied that there are as many [squares] as there are numbers because every number is a [square] root of some square: 1 ↔ 1, 2 ↔ 4, 3 ↔ 9, 4 ↔ 16, and so on.

(In modern language, there is a bijection between the elements of the set of positive integers N and the set of squares S, and S is a proper subset of density zero.) But he notes what appears to be a contradiction:

Yet at the outset we said there are many more numbers than squares, since the larger portion of them are not squares. Not only so, but the proportionate number of squares diminishes as we pass to larger numbers.

He resolves the contradiction by denying the possibility of comparing infinite numbers (and of comparing infinite and finite numbers):

We can only infer that the totality of all numbers is infinite, that the number of squares is infinite, and that the number of their roots is infinite; neither is the number of squares less than the totality of all numbers, nor the latter greater than the former; and finally the attributes "equal," greater," and "less," are not applicable to infinite, but only to finite, quantities.

This conclusion, that ascribing sizes to infinite sets should be ruled impossible, owing to the contradictory results obtained from these two ostensibly natural ways of attempting to do so, is a resolution to the problem that is consistent with, but less powerful than, the methods used in modern mathematics. The resolution to the problem may be generalized by considering Galileo's first definition of what it means for sets to have equal sizes, that is, the ability to put them in one-to-one correspondence. This turns out to yield a way of comparing the sizes of infinite sets that is free from contradictory results.

These issues of infinity arise from problems of rolling circles. If two concentric circles of different radii roll along lines, then if the larger does not slip it appears clear that the smaller must slip. But in what way? Galileo attempts to clarify the matter by considering hexagons and then extending to rolling 100 000-gons, or n-gons, where he shows that a finite number of finite slips occur on the inner shape. Eventually, he concludes "the line traversed by the larger circle consists then of an infinite number of points which completely fill it; while that which is traced by the smaller circle consists of an infinite number of points which leave empty spaces and only partly fill the line," which would not be considered satisfactory now.

Reactions by commentators

‘So great a contribution to physics was *Two New Sciences* that scholars have long maintained that the book anticipated Isaac Newton's laws of motion.’

<<< *Stephen Hawking*

‘Galileo ... is the father of modern physics—indeed of modern science’

<<< *Albert Einstein*

Part of *Two New Sciences* was pure mathematics, as has been pointed out by the mathematician Alfréd Rényi, who said that it was the most significant book on mathematics in over 2000 years: Greek mathematics did not deal with motion, and so they never formulated mathematical laws of motion, even though Archimedes developed differentiation and integration. *Two New Sciences* opened the way to treating physics mathematically by treating motion mathematically for the first time. The Greek mathematician Zeno had designed his paradoxes to prove that motion could not be treated mathematically, and that any attempt to do so would lead to paradoxes. (He regarded this as an inevitable limitation of mathematics.) Aristotle reinforced this belief, saying that mathematic could only deal with abstract objects that were immutable. Galileo used the very methods of the Greeks to show that motion could indeed be treated mathematically. His idea was to separate out the paradoxes of the infinite from Zeno's paradoxes. He did this in several steps. First, he showed that the infinite sequence S of the squares 1, 4, 9, 16, ...contained as many elements as the sequence N of all positive integers (infinity); this is now referred to as Galileo's

paradox. Then, using Greek style geometry, he showed a short line interval contained as many points as a longer interval. At some point he formulates the general principle that a smaller infinite set can have just as many points as a larger infinite set containing it. It was then clear that Zeno's paradoxes on motion resulted entirely from this paradoxical behavior of infinite quantities. Renyi said that, having removed this 2000-year-old stumbling block, Galileo went on to introduce his mathematical laws of motion, anticipating Newton.

Gassendi's thoughts

Pierre Gassendi defended Galileo's opinions in his book, *De Motu Impresso a Motore Translato*. In Howard Jones' article, *Gassendi's Defence of Galileo: The Politics of Discretion*, Jones says Gassendi displayed an understanding of Galileo's arguments and a clear grasp of their implications for the physical objections to the earth's motion.

Koyré's thoughts

The law of falling bodies was published by Galileo in 1638. But in the 20th century some authorities challenged the reality of Galileo's experiments. In particular, the French historian of science Alexandre Koyré bases his doubt on the fact that the experiments reported in *Two New Sciences* to determine the law of acceleration of falling bodies, required accurate measurements of time which appeared to be impossible with the technology of 1600. According to Koyré, the law was created deductively, and the experiments were merely illustrative thought experiments. In fact, Galileo's water clock (described above) provided sufficiently accurate measurements of time to confirm his conjectures.

Later research, however, has validated the experiments. The experiments on falling bodies (actually rolling balls) were replicated using the methods described by Galileo, and the precision of the results was consistent with Galileo's report. Later research into Galileo's unpublished working papers from 1604 clearly showed the reality of the experiments and even indicated the particular results that led to the time-squared law.

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Galileo Affair

https://en.wikipedia.org/wiki/Galileo_affair

The **Galileo affair** (Italian: *il processo a Galileo Galilei*) began around 1610, and culminated with the trial and condemnation of Galileo Galilei by the Roman Catholic Inquisition in 1633. Galileo was prosecuted for holding as true the doctrine of heliocentrism, the astronomical model in which the Earth and planets revolve around the Sun at the centre of the universe.

In 1610, Galileo published his *Sidereus Nuncius* (*Starry Messenger*), describing the observations that he had made with his new, much stronger telescope, amongst them, the Galilean moons of Jupiter. With these observations and additional observations

that followed, such as the phases of Venus, he promoted the heliocentric theory of Nicolaus Copernicus published in *De revolutionibus orbium coelestium* in 1543. Galileo's opinions were met with opposition within the Catholic Church, and in 1616 the Inquisition declared heliocentrism to be "formally heretical". Galileo went on to propose a theory of tides in 1616, and of comets in 1619; he argued that the tides were evidence for the motion of the Earth.

In 1632, Galileo published his *Dialogue Concerning the Two Chief World Systems*, which defended heliocentrism, and was immensely popular. Responding to mounting controversy over theology, astronomy and philosophy, the Roman Inquisition tried Galileo in 1633, found him "vehemently suspect of heresy", and sentenced him to house arrest where he remained until his death in 1642. At that point, heliocentric books were banned and Galileo was ordered to abstain from holding, teaching or defending heliocentric ideas after the trial.

The affair was complex since very early on Pope Urban VIII had been a patron to Galileo and had given him permission to publish on the Copernican theory as long as he treated it as a hypothesis, but after the publication in 1632, the patronage was broken off due to numerous reasons. Historians of science have corrected numerous false interpretations of the affair.

Galileo before the Holy Office, a 19th-century painting.

List of Artistic Treatments

Self-Portrait in a Circle of Friends from Mantua

Galilei is the third man on the left.

In addition to the large non-fiction literature and the many documentary films about Galileo and the Galileo affair, there have also been several treatments in historical plays and films. The Museo Galileo has posted a listing of several of the plays. A listing centered on the films was presented in a 2010 article by Cristina Olivotto and Antonella Testa.

- *Galilée* is a French play by François Ponsard first performed in 1867.
- *Galileo Galilei* is a short Italian silent film by Luigi Maggi that was released in 1909.
- *Life of Galileo* is a play by the German playwright Bertolt Brecht that exists in several versions, including a 1947 version in English written with Charles Laughton. The play has been called "Brecht's masterpiece" by Michael Billington of *The Guardian* British newspaper. Joseph Losey, who directed the first productions of the English language version in 1947, made a film based on the play that was released in 1975.
- *Lamp at Midnight* is a play by Barrie Stavis that was first performed in 1947. An adaptation of the play was televised in 1964; it was directed by George Schaefer. A recording was released as a VHS tape in the 1980s.
- *Galileo* is a 1968 Italian film written and directed by Liliana Cavani.
- *Galileo Galilei* is an opera with music by Philip Glass and a libretto by Mary Zimmerman. It was first performed in 2002.

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Life of Galileo

https://en.wikipedia.org/wiki/Life_of_Galileo

Life of Galileo

1971 Berliner Ensemble production

Written by	Bertolt Brecht
Characters	• Galileo • Andrea Sarti • Mrs Sarti

	- Ludovico Marsili - Virginia - Sagredo - Federzoni - Mr Priuli - Cosimo de Medici - Father Christopher Clavius - Cardinal Barberini - Fillipo Mucius - Mr Gaffone - Vanni - Senator - 1st Monk - Puppeteer - Rector
Date premiered	1943
Original language	German
Subject	Social responsibility of scientists
Genre	Epic theatre[1]
Setting	Renaissance Italy

Life of Galileo (German: *Leben des Galilei*), also known as ***Galileo***, is a play by the 20th century German dramatist Bertolt Brecht and collaborator Margarete Steffin with incidental music by Hanns Eisler. The play was written in 1938 and received its first theatrical production (in German) at the Zurich Schauspielhaus, opening on the 9th of September 1943. This production was directed by Leonard Steckel, with set-design by Teo Otto. The cast included Steckel himself (as Galileo), Karl Paryla and Wolfgang Langhoff.

The second (or "American") version was written in English between 1945–1947 in collaboration with Charles Laughton, and opened at the Coronet Theatre in Los Angeles on 30 July 1947. It was directed by Joseph Losey and Brecht, with musical direction by Serge Hovey and set-design by Robert Davison. Laughton played Galileo, with Rusty Lane as Barberini and Joan McCracken as Virginia. This production opened at the Maxine Elliott's Theatre in New York on 7 December of the same year.

In 1955 Brecht prepared a third version. A production, by the Berliner Ensemble with Ernst Busch in the title role, opened in January 1957 at the Theater am Schiffbauerdamm and was directed by Erich Engel, with set-design by Caspar Neher. The play was first published in 1940.

The action of the play follows the career of the great Italian natural philosopher Galileo Galilei and the Galileo affair, in which he was tried by the Roman Catholic Church for the promulgation of his scientific discoveries. The play embraces such themes as the conflict between dogmatism and scientific evidence, as well as interrogating the values of constancy in the face of oppression.

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Lamp At Midnight

https://en.wikipedia.org/wiki/Lamp_At_Midnight

Lamp at Midnight	
Directed by	George Schaefer
Screenplay by	Robert Hartung
Based on	*Lamp at Midnight* by Barrie Stavis
Starring	Melvyn Douglas Kim Hunter Hurd Hatfield William Kerwin
Music by	Bernard Green
Release date	• 1966
Running time	76 minutes
Country	United States
Language	English

Lamp At Midnight is a play that was written by Barrie Stavis, and first produced in 1947 at New Stages, New York. The play treats the 17th Century Galileo affair, which was a profound conflict between the Roman Catholic Church and Galileo Galilei over the interpretation of his astronomical observations using the newly invented telescope. By coincidence, Bertolt Brecht's play on the same theme, *Life of Galileo*, opened in New York just a few weeks before *Lamp at Midnight*. Some critics now consider *Galileo* to be a masterpiece, but in 1947 the *New York Times* reviewer, Brooks Atkinson, preferred *Lamp at Midnight*.

A revival of *Lamp at Midnight* directed by Sir Tyrone Guthrie and starring Morris Carnovsky toured the United States in 1969.

Adaptation for television

A television adaptation, directed by George Schaefer and starring Melvyn Douglas as Galileo, appeared in the *Hallmark Hall of Fame* series in 1966. A recording of the television performance was released to video in 1983.

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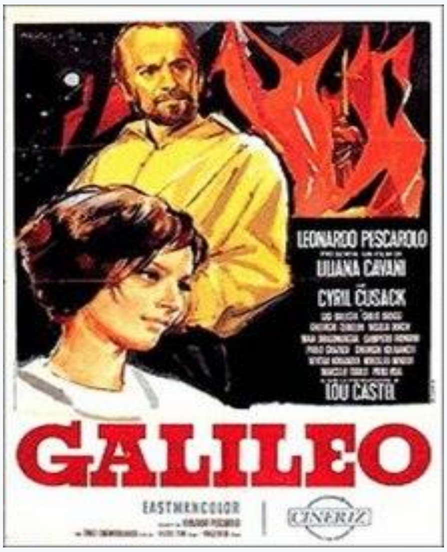
GALILEO

(1968 film)

https://en.wikipedia.org/wiki/Galileo_(1968_film)

Galileo



Directed by	Liliana Cavani
Written by	Liliana Cavani Tullio Pinelli Fabrizio Onofri
Produced by	Leo Pescarolo
Starring	Cyril Cusack Georgi Kaloyanchev Piero Vida
Cinematography	Alfio Contini
Edited by	Nino Baragli
Music by	Ennio Morricone
Production companies	Rizzoli Film Fenice Cinematografica Kinozenter
Distributed by	Cineriz
Release date	• 1968
Running time	105/92 minutes
Countries	Italy Bulgaria
Language	Italian

Galileo (also known as *Galileo Galilei*) is a 1968 Italian–Bulgarian biographical drama film directed by Liliana Cavani. It depicts the life of Galileo Galilei and particularly his conflicts with the Catholic Church over his scientific theories.

Plot

Astronomer Galileo Galilei teaches at the University of Padua. While he questions the ideas of Ptolemy and Aristotle, the official scientific dogmas imposed by the Catholic Church, he remains secretive about his doubts. His more candid friend, philosopher Giordano Bruno, is reported to

the Inquisition for his revolutionary ideas and later executed as a heretic. Still, Galileo continues his studies with a telescope constructed by Dutch technicians and perfected by him, and comes to the conclusion that Copernico's heliocentric system is valid. He publishes his discoveries in a book, which leads to a series of interrogations by the Inquisition. Facing a possible death sentence, Galileo publicly recants his theories.

Cast

- Cyril Cusack as Galileo Galilei
- Georgi Kaloyanchev as Giordano Bruno
- Nevena Kokanova as Marina
- Nicolai Doicev as Cardinal Bellarmino
- Georgi Cherkelov as Paolo Sarpi
- Piero Vida as Pope Urban VIII
- Gigi Ballista as Dominican Commissioner
- Paolo Graziosi as Gian Lorenzo Bernini
- Maia Dragomanska as Galilei's daughter
- Lou Castel as Father Charles
- Giulio Brogi as Sagredo

Production and release

Originally intended as a miniseries co-produced by Italian and Bulgarian film companies, radio and television company RAI refused to broadcast the finished film and sold the distribution rights to Cineriz, who trimmed the originally 105 minutes long film to 92 minutes running time.

Galileo was shown in competition at the 1968 Venice International Film Festival.

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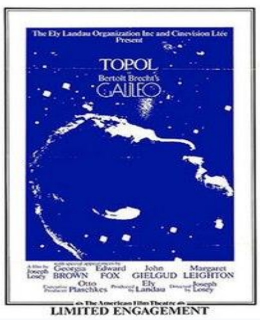
Galileo

(1975 film)

https://en.wikipedia.org/wiki/Galileo_(1975_film)

Galileo



Theatrical release poster (1974)

Directed by	Joseph Losey
Written by	Joseph Losey Barbara Bray
Based on	*Galileo* by Bertolt Brecht with Charles Laughton (trans.)
Produced by	Ely Landau
Starring	Topol Georgia Brown Edward Fox John Gielgud Margaret Leighton
Cinematography	Michael Reed
Edited by	Reginald Beck
Music by	Hanns Eisler Richard Hartley
Distributed by	American Film Theatre
Release date	• 27 January 1975 (US)
Running time	145 minutes
Country	United Kingdom
Language	English
Box office	$1,185,607 (gross)

Galileo is a 1975 biographical film about the 16th- and 17th-century scientist Galileo Galilei, whose astronomical observations with the newly invented telescope led to a profound conflict with the Roman Catholic Church. The film is an adaptation of Bertolt Brecht's 1943 play of the same name. The film was produced by Ely Landau for the American Film Theatre, which presented thirteen film adaptations of plays in the United States from 1973 to 1975. Brecht's play was recently called a "masterpiece" by veteran theater critic Michael Billington, as Martin Esslin had in 1960. The film's director, Joseph Losey, had also directed the first performances of the play in 1947 in the US — with Brecht's active participation. The film is fairly true to those first performances, and is thus of historical significance as well.

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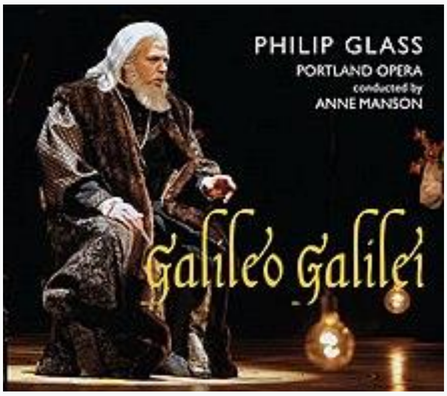
Galileo Galilei

(Opera)

https://en.wikipedia.org/wiki/Galileo_Galilei_(opera)

Galileo Galilei is an opera based on excerpts from the life of Galileo Galilei, which premiered in 2002 at Chicago's Goodman Theatre, as well as subsequent presentations

at the Brooklyn Academy of Music's New Wave Music Festival and London's Barbican Theatre. The music is by Philip Glass, with libretto and original direction by Mary Zimmerman and Arnold Weinstein. The piece is presented in one act, consisting of ten scenes without break.

Galileo Galilei	
Opera by Philip Glass	
	
Glass in 2006	
Librettist	Mary Zimmerman Arnold Weinstein
Based on	life of Galileo Galilei
Premiere	2002 Goodman Theatre, Chicago

Galileo Galilei is Glass' s 18th opera. The libretto draws from letters of Galileo and his family, and various other documents, to retrospectively journey through Galileo's life. Opening with him as an old, blind man after the trial and Inquisition for his heresy, it explores his religiosity as well as his break with the church. It expands into the greater, oscillating relationship of science to both religion and art. It reaches its end with Galileo — as a young boy — watching an opera composed by his father, Vincenzo Galilei, who was a member of the Florentine Camerata, an association of artists who are credited with creating the art form that came to be known as opera. His father's opera was about the motions of the celestial bodies.

The opera has been revived with new productions in 2012 by Madison Opera and Portland Opera. The Portland Opera production was recorded by Orange Mountain Music. Opera Theatre of Saint Louis is staging it in June 2024.

Production notes

All genius meets with extreme resistance before it is accepted as truth. In the case of Galileo, it was the mere hypothesis that the Earth revolved around the Sun. The notion was considered heretical and blasphemous by

scholars and clergy alike. Much was done to destroy Galileo's reputation. And since they could not do so through scientific proof, they did so through slander and threats of torture. It was not until recently that the Catholic Church finally admitted that they were wrong in persecuting Galileo. It took hundreds of years for them to admit the mistake. Galileo died believing that all of the advancements he had made in science were for naught. His books were banned, and his name was disgraced. All of this, for suggesting a theory that turned out to be true.

In addition to depicting Galileo's trials before the Inquisition, the opera also allows us a glance into Galileo's more personal side. Namely, in showing us his relationship to his daughter Maria Celeste, who was a nun. Maria Celeste shared her father's love of learning and science, but also understood that he was a man of great faith. She recognized that science was the very subject that served to deepen his faith, and she encouraged him on this path. The two met rarely. They were separated not only by distance, but by Galileo's often ailing health. Sadly, they were ultimately separated by her death at the age of 33, a source of incredible sadness for Galileo. However, their connection in this opera serves to give his story a more personal rendering. The story itself is told backwards through time. It begins with an aged Galileo, blinded from having looked at the Sun too often and ends with him as a child. This is related to the function of a telescope, which works by reversing images with lenses. Much of the staging in this production is representative of Galileo's theories and follows the patterns of the discoveries, planets, and constellations that his inventions made known to the world.[1]

Synopsis

Scene 1

Opening Song

In the final days of his life, the now blind Galileo Galilei remembers the things in his life that he can no longer see.

Scene 2

Recantation

The officials of the Catholic Church rebuke the scientist for not relenting on his theory that the Earth revolves around the Sun. The Pope hands down his sentence, and then reminds Galileo of a time when they walked in the garden as friends.

Scene 3

Pears

Maria Celeste, the daughter of Galileo, sends her intense devotion love and support through letters that are accompanied by elements of her garden at the convent.

Scene 4

Trial

Galileo is summoned before two Cardinals of the Catholic Church to answer questions regarding his book "Dialogue Concerning the Two Chief Systems of the World".

Scene 5

Dialogue Concerning the Two Chief Systems of the World

As Galileo pens his book, the fictitious characters come alive to discuss the theories presented. *Here, the Older Galileo becomes the Younger Galileo.*

Scene 6

Incline Plane

The theories and experiments are put to the test in Galileo's laboratory.

Scene 7

A Walk in the Garden

Galileo and his great friend Cardinal Barberini discuss Galileo's newest book in the Garden. After the Cardinal's feeble attempt at poetry, Galileo expresses his fear of his enemies. Barberini warns Galileo not to continue with his theories regarding the planets.

Scene 8

Lamps

While at mass with his daughter, Galileo observes the swinging of a lamp suspended from the ceiling moving in pendulum fashion and explains his theory to Maria Celeste.

Scene 9

Presentation of the Telescope

Galileo presents his invention to the Duchess and her Ladies in Waiting. The Duchess and Galileo reminisce about a time in their youth when they watched an opera together composed by Galileo's father, Vincenzo.

Scene 10

Opera within the Opera

The Duchess and Galileo, now children, are in the audience as his father's opera is performed. The magical story of the planetary figures becomes the vehicle through which Galileo is reunited with his deceased daughter.

Kindly visit these Web Links and see these Videos

01] Galileo Movie (1975) [2:25:04]

https://www.youtube.com/watch?v=VgAZonVsuQE

02] Galileo's Battle for the Heavens [3:00:55]

https://www.youtube.com/watch?v=PEcSkKIoEtc

03] Galileo Galilei by Brecht [2:01:4]
https://www.youtube.com/watch?v=F_mI1CEDlBk

04] History of Telescopes [52:58]
https://www.youtube.com/watch?v=R4F0T86RAM4

05] PBS Nova Documentary Collection: Galileo's Battle for the ... [1:48:56]
https://www.youtube.com/watch?v=2NflFe_xcGU

06] Galileo - An Educational Film [57:58]
https://www.youtube.com/watch?v=RxJsCgMUPUU

07] Galileo Galilei - Days that shook the world [28:30]
https://www.dailymotion.com/video/x6gljar

08] Galileo Galilei: Father of Modern Science [24:37]
https://www.youtube.com/watch?v=5eMYZCnNALc

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Museo Galileo

https://en.wikipedia.org/wiki/Museo_Galileo

Museo Galileo

Institute and Museum of the History of Science

Museo Galileo (formerly *Istituto e Museo di Storia della Scienza*; **Institute and Museum of the History of Science**) is located in Florence, Italy, in Piazza dei Giudici, along the River Arno and close to the Uffizi Gallery. The museum, dedicated to astronomer and scientist Galileo Galilei, is housed in Palazzo Castellani, an 11th-century building which was then known as the Castello d'Altafronte.

Museo Galileo owns one of the world's major collection of scientific instruments, which bears evidence of the role that the Medici and Lorraine Grand Dukes attached to science and scientists.

The Museo di Storia della Scienza has re-opened to the public under the new name *Museo Galileo* since June 10, 2010, after a two-year closure due to redesigning and renovation work. Its name change celebrates the 400-year anniversary of Galileo's *Sidereus Nuncius* (*The Starry Messenger*), first published in March of 1610.

The museum

The museum features the valuable scientific instruments from the Medici Collections which were first displayed in the Stanzino delle Matematiche (Mathematics Room) in the Uffizi Gallery. They were later on moved to the Museo di Fisica e Storia Naturale (Museum of Physics and Natural History) founded by Grand Duke Peter Leopold in 1775. During the reign of the Lorraine Grand Dukes, new instruments were added to the scientific collections. In 1929, the First Italian Exhibition of the History of Science in Florence highlighted the importance of scientific collections within Italy's cultural heritage. As a consequence, in 1930 the University of Florence gave birth to the Istituto di Storia della Scienza con annesso Museo (Institute of the History of Science and attached Museum). The institute was housed in Palazzo Castellani and was entrusted with the instrument collections of the Medici and Lorraine dynasties. The permanent exhibition is arranged by chronological and thematic paths.[1]

The museum directors

1930-1961 Andrea Corsini

1961-1981 Maria Luisa Righini Bonelli

1982-2021 Paolo Galluzzi

since 2021 Roberto Ferrari (Executive Director)

from July until December 2021 Marco Ciardi (Scientific Director)

since December 2021 Filippo Camerota (Scientific Director)

The Medici Collection

The first floor's nine rooms are devoted to the Medici Collections, dating from the 15th century through the 18th century. The permanent exhibition includes all of Galileo's unique artifacts, among which are his only two

extant telescopes and the framed objective lens from the telescope with which he discovered the Galilean moons of Jupiter; thermometers used by members of the Accademia del Cimento; and an extraordinary collection of terrestrial and celestial globes, including Santucci's Armillary Sphere, a giant armillary sphere designed and built by Antonio Santucci.

The Lorraine Collection

The nine rooms on the second floor house instruments and experimental apparatus collected by the Lorraine dynasty (18th-19th century), which bear witness of the remarkable contribution of Tuscany and Italy to the progress of electricity, electromagnetism and chemistry. The exhibits include obstetrical wax models from Santa Maria Nuova Hospital, Grand Duke Peter Leopold's chemistry cabinet and the beautiful machines made in the workshop of the Museo di Fisica e Storia Naturale to illustrate the fundamental physical laws.

Research and documentation

Museo Galileo carries out research and documentation in the history of science and technology, as well as in the field of preservation and improvement of museum collections. The library's book collection and a number of online resources are available to scholars. The museum is partner with important institutions, such as the Royal Swedish Academy of Sciences, the Nobel Foundation, the Max Planck Society's institutes and the Harvard University, and co-sponsors several research projects. It also organizes and takes part in many conferences on scientific museology and the history of science and technology.

Temporary exhibitions

Museo Galileo has been enhancing and promoting the dissemination of scientific culture for many years. In order to meet this commitment effectively, it promotes exhibitions on the history of science and the relationship between science, technology and art.[2] Among the most important exhibitions in Italy and the world: *Renaissance Engineers: From Brunelleschi to Leonardo da Vinci*; *The Mind of Leonardo: The Universal Genius at Work*; *The Medici and Science*; *Galileo's Telescope: The Instrument that Changes the World*; *Galileo: Images of the Universe from Antiquity to the Telescope*; *Vinum Nostrum: Art, Science and Myths of Wine in Ancient Mediterranean Cultures*; *Archimedes: The Art and Science of Invention*, and the most recent (2019-2020) *Water as Microscope of Nature: Leonardo da Vinci's Codex Leicester*, *Leonardo and His Books: The Library of the Universal Genius*, *Leonardo da Vinci and Perpetual Motion*, *The Art of Building a Masterpiece: Trajan Column*.

Publications

Museo Galileo publishes historical scientific works and two journals, which are *Nuncius: Journal of the Material and Visual History of Science*, and *Galilaeana*, devoted to research about the figure, work and scientific

findings of Galileo Galilei. The Nuncius Library series publishes the results of original research in the history of science and technology as well as editions of sources, while the Galilaeana Library series publishes critical essays, document collections and text editions related to Galileo and to the cultural scenario of the early modern period. To be mentioned also the Archive of Italian Scientists' Correspondence and the Italian Science Library series.[3] In addition, the museum publishes catalogues relevant to its collections and the temporary exhibitions it promotes.

The library

The library—which has been a part of the institute since its foundation—was completely remodelled in 2002, when it was moved to the third floor of Palazzo Castellani. The new architectural set-up was awarded the "Bibliocom Biblioteche in vetrina" prize. The library houses about 150,000 works concerning the history of science. The antique book collection consists of nearly 5,000 works. It includes the Medici-Lorraine Collection, made of scientific books mostly about physics and mathematics, gathered by Tuscan dynasties over five centuries. The library is also home to several 18th- to 20th-century archival collections and a photo archive related to the history of the museum's collections, ancient instruments and places of scientific interest. The contemporary collection includes books in Italian and the major European languages and has an annual growth of about 1,800 new acquisitions.[4] All of the library's material can be searched on the online catalogue. Among the library's activities are the compiling of bibliographies –notably the International Galilaean Bibliography– and the cataloguing of documents relevant to the history of science, even not in the library's possession. In 2004, a Digital Library was created to preserve and publish digital collections of historical scientific interest.[5]

The Multimedia Lab

Aware of the growing importance of information and communication technologies, Museo Galileo started its own Multimedia Lab in 1991. The Lab produces offline and online interactive applications related to the dissemination and documentation of both permanent collections and temporary exhibitions. It also creates digital archives for historical scientific research.

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Writings

https://en.wikipedia.org/wiki/Galileo_Galilei

Galileo's early works describing scientific instruments include the 1586 tract entitled *The Little Balance* (*La Billancetta*) describing an accurate balance to weigh objects in air or water and

the 1606 printed manual *Le Operazioni del Compasso Geometrico et Militare* on the operation of a geometrical and military compass.

Statue outside the Uffizi, Florence

Statue of Galileo by Pio Fedi (1815–1892) inside the Lanyon Building of the Queen's University Belfast. Sir William Whitla (Professor of Materia Medica 1890–1919) brought the statue back from Italy and donated it to the university.

His early works on dynamics, the science of motion and mechanics were his *circa* 1590 Pisan *De Motu* (On Motion) and his *circa* 1600 Paduan *Le Meccaniche* (Mechanics). The former was based on Aristotelian–Archimedean fluid dynamics and held that the speed of gravitational fall in a fluid medium was proportional to the excess of a body's specific weight over that of the medium, whereby in a vacuum, bodies would fall with speeds in proportion to their specific weights. It also subscribed to the Philoponan impetus dynamics in which impetus is self-dissipating and free-

fall in a vacuum would have an essential terminal speed according to specific weight after an initial period of acceleration.

Galileo's 1610 *The Starry Messenger* (*Sidereus Nuncius*) was the first scientific treatise to be published based on observations made through a telescope. It reported his discoveries of:

- the Galilean moons
- the roughness of the Moon's surface
- the existence of a large number of stars invisible to the naked eye, particularly those responsible for the appearance of the Milky Way
- differences between the appearances of the planets and those of the fixed stars—the former appearing as small discs, while the latter appeared as unmagnified points of light

Galileo published a description of sunspots in 1613 entitled *Letters on Sunspots* suggesting the Sun and heavens are corruptible. The *Letters on Sunspots* also reported his 1610 telescopic observations of the full set of phases of Venus, and his discovery of the puzzling "appendages" of Saturn and their even more puzzling subsequent disappearance. In 1615, Galileo prepared a manuscript known as the "Letter to the Grand Duchess Christina" which was not published in printed form until 1636. This letter was a revised version of the *Letter to Castelli*, which was denounced by the Inquisition as an incursion upon theology by advocating Copernicanism both as physically true and as consistent with Scripture.[245] In 1616, after the order by the Inquisition for Galileo not to hold or defend the Copernican position, Galileo wrote the "Discourse on the Tides" (*Discorso sul flusso e il reflusso del mare*) based on the Copernican earth, in the form of a private letter to Cardinal Orsini.[246] In 1619, Mario Guiducci, a pupil of Galileo's, published a lecture written largely by Galileo under the title *Discourse on the Comets* (*Discorso Delle Comete*), arguing against the Jesuit interpretation of comets.

In 1623, Galileo published *The Assayer—Il Saggiatore*, which attacked theories based on Aristotle's authority and promoted experimentation and the mathematical formulation of scientific ideas. The book was highly successful and even found support among the higher echelons of the Christian church. Following the success of *The Assayer*, Galileo published the *Dialogue Concerning the Two Chief World Systems* (*Dialogo sopra i due massimi sistemi del mondo*) in 1632. Despite taking care to adhere to the Inquisition's 1616 instructions, the claims in the book favouring Copernican theory and a non-geocentric model of the solar system led to Galileo being tried and banned from publication. Despite the publication ban, Galileo published his *Discourses and Mathematical Demonstrations Relating to Two New Sciences* (*Discorsi e Dimostrazioni Matematiche, intorno a due nuove scienze*) in 1638 in Holland, outside the jurisdiction of the Inquisition.

Published written works

Galileo's main written works are as follows:

- *The Little Balance* (1586; in Italian: *La Bilancetta*)
- *On Motion* (c. 1590; in Latin: *De Motu Antiquiora*)
- *Mechanics* (c. 1600; in Italian: *Le Meccaniche*)
- *The Operations of Geometrical and Military Compass* (1606; in Italian: *Le operazioni del compasso geometrico et militare*)
- *The Starry Messenger* (1610; in Latin: *Sidereus Nuncius*)
- *Discourse on Floating Bodies* (1612; in Italian: *Discorso intorno alle cose che stanno in su l'acqua, o che in quella si muovono*, "Discourse on Bodies that Stay Atop Water, or Move in It")
- *History and Demonstration Concerning Sunspots* (1613; in Italian: *Istoria e dimostrazioni intorno alle macchie solari*; work based on the *Three Letters on Sunspots*, *Tre lettere sulle macchie solari*, 1612)
- "Letter to the Grand Duchess Christina" (1615; published in 1636)
- "Discourse on the Tides" (1616; in Italian: *Discorso del flusso e reflusso del mare*)
- *Discourse on the Comets* (1619; in Italian: *Discorso delle Comete*)
- *The Assayer* (1623; in Italian: *Il Saggiatore*)
- *Dialogue Concerning the Two Chief World Systems* (1632; in Italian: *Dialogo sopra i due massimi sistemi del mondo*)
- *Discourses and Mathematical Demonstrations Relating to Two New Sciences* (1638; in Italian: *Discorsi e Dimostrazioni Matematiche, intorno a due nuove scienze*)

Personal library

In the last years of his life, Galileo Galilei kept a library of at least 598 volumes (560 of which have been identified) at Villa Il Gioiello, on the outskirts of Florence. Under the restrictions of house arrest, he was forbidden to write or publish his ideas. However, he continued to receive visitors right up to his death and it was through them that he remained supplied with the latest scientific texts from Northern Europe.

Galileo's will does not refer to his collection of books and manuscripts. An itemized inventory was only later produced after Galileo's death, when the majority of his possessions including his library passed to his son, Vincenzo Galilei Jr. On his death in 1649, the collection was inherited by his wife Sestilia Bocchineri.

Galileo's books, personal papers and unedited manuscripts were then collected by Vincenzo Viviani, his former assistant and student, with the intent of preserving his old teacher's works in published form. It was a project that never materialised and in his final will, Viviani bequeathed a significant portion of the collection to the Hospital of Santa Maria Nuova in Florence, where there already existed an extensive library. The value of

Galileo's possessions was not realised, and duplicate copies were dispersed to other libraries, such as the Biblioteca Comunale degli Intronati, the public library in Sienna. In a later attempt to specialise the library's holdings, volumes unrelated to medicine were transferred to the Biblioteca Magliabechiana, an early foundation for what was to become the *Biblioteca Nazionale Centrale di Firenze*, the National Central Library in Florence.

A small portion of Viviani's collection, including the manuscripts of Galileo and those of his peers Evangelista Torricelli and Benedetto Castelli, was left to his nephew, Abbot Jacopo Panzanini. This minor collection was preserved until Panzanini's death when it passed to his great-nephews, Carlo and Angelo Panzanini. The books from both Galileo and Viviani's collections began to disperse as the heirs failed to protect their inheritance. Their servants sold several of the volumes for waste paper. Around 1750 the Florentine senator Giovanni Battista Clemente de'Nelli heard of this and purchased the books and manuscripts from the shopkeepers, and the remainder of Viviani's collection from the Panzanini brothers. As recounted in Nelli's memoirs: *"My great fortune in obtaining such a wonderful treasure so cheaply came about through the ignorance of the people selling it, who were not aware of the value of those manuscripts..."*

The library remained in Nelli's care until his death in 1793. Knowing the value of their father's collected manuscripts, Nelli's sons attempted to sell what was left to them to the French government. Ferdinand III, Grand Duke of Tuscany intervened in the sale and purchased the entire collection. The archive of manuscripts, printed books and personal papers was deposited with the Biblioteca Palatina in Florence, merging the collection with the Biblioteca Magliabechiana in 1861.

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Some IMPORTANT Web Links

https://plato.stanford.edu/entries/galileo/

https://www.history.com/topics/inventions/galileo-galilei

https://www.bbc.co.uk/history/historic_figures/galilei_galileo.shtml

https://www.newscientist.com/people/galileo-galilei/

https://starchild.gsfc.nasa.gov/docs/StarChild/whos_who_level2/galileo.html

https://nmspacemuseum.org/inductee/galileo-galilei/

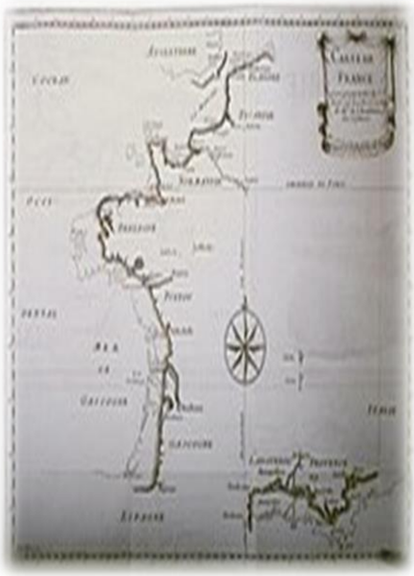
https://www.worldhistory.org/Galileo_Galilei/

https://www2.hao.ucar.edu/education/scientists/galileo-galilei-1564-1642

https://www.loc.gov/collections/finding-our-place-in-the-cosmos-with-carl-sagan/articles-and-essays/modeling-the-cosmos/galileo-and-the-telescope

Portrait believed to be of Galileo's elder daughter Virginia, who was particularly devoted to her father.

An illustration of the Moon from *Sidereus Nuncius*, published in Venice, 1610



Map of France presented in 1684, showing the outline of an earlier map (light outline) compared to a new survey conducted using the moons of Jupiter as an accurate timing reference (heavier outline)

Galileo's "cannocchiali" telescopes at the Museo Galileo, Florence

Portrait, originally attributed to Murillo, of Galileo gazing at the words "E pur si muove" (*And yet it moves*) (not legible in this image) scratched on the wall of his prison cell. The attribution and narrative surrounding the painting have since been contested.

Cristiano Banti's 1857 painting *Galileo facing the Roman Inquisition*

Galileo's middle finger from his right hand

Tomb of Galileo, Santa Croce, Florence

Galileo's geometrical and military compass, thought to have been made c. 1604 by his personal instrument-maker Marc'Antonio Mazzoleni

A replica of the earliest surviving telescope attributed to Galileo Galilei, on display at the Griffith Observatory

Legacy

https://en.wikipedia.org/wiki/Galileo_Galilei

Later Church reassessments

The Galileo affair was largely forgotten after Galileo's death, and the controversy subsided. The Inquisition's ban on reprinting Galileo's works was lifted in 1718 when permission was granted to publish an edition of his works (excluding the condemned *Dialogue*) in Florence. In 1741, Pope Benedict XIV authorised the publication of an edition of Galileo's complete scientific works which included a mildly censored version of the *Dialogue*. In 1758, the general prohibition against works advocating heliocentrism was removed from the Index of prohibited books, although the specific ban on uncensored versions of the *Dialogue* and Copernicus's *De Revolutionibus* remained. All traces of official opposition to heliocentrism by the church disappeared in 1835 when these works were finally dropped from the Index.

Interest in the Galileo affair was revived in the early 19th century when Protestant polemicists used it (and other events such as the Spanish Inquisition and the myth of the flat Earth) to attack Roman Catholicism.[10] Interest in it has waxed and waned ever since. In 1939, Pope Pius XII, in his first speech to the Pontifical Academy of Sciences, within a few months of his election to the papacy, described Galileo as being among the "most audacious heroes of research... not afraid of the stumbling blocks and the risks on the way, nor fearful of the funereal monuments".[228] His close advisor of 40 years, Professor Robert Leiber, wrote: "Pius XII was very careful not to close any doors (to science) prematurely. He was energetic on this point and regretted that in the case of Galileo."

On 15 February 1990, in a speech delivered at the Sapienza University of Rome, Cardinal Ratzinger (later Pope Benedict XVI) cited some current views on the Galileo affair as forming what he called "a symptomatic case that permits us to see how deep the self-doubt of the modern age, of science and technology goes today". Some of the views he cited were those of the philosopher Paul Feyerabend, whom he quoted as saying: "The Church at the time of Galileo kept much more closely to reason than did Galileo himself, and it took into consideration the ethical and social consequences of Galileo's teaching too. Its verdict against Galileo was rational and just and the revision of this verdict can be justified only on the grounds of what is politically opportune." The Cardinal did not clearly indicate whether he agreed or disagreed with Feyerabend's assertions. He did, however, say: "It would be foolish to construct an impulsive apologetic on the basis of such views."

On 31 October 1992, Pope John Paul II acknowledged that the Inquisition had erred in condemning Galileo for asserting that the Earth revolves around the Sun. "John Paul said the theologians who condemned Galileo did not recognize the formal distinction between the Bible and its interpretation."

In March 2008, the head of the Pontifical Academy of Sciences, Nicola Cabibbo, announced a plan to honour Galileo by erecting a statue of him inside the Vatican walls. In December of the same year, during events to mark the 400th anniversary of Galileo's earliest telescopic observations, Pope Benedict XVI praised his contributions to astronomy. A month later, however, the head of the Pontifical Council for Culture, Gianfranco Ravasi, revealed that the plan to erect a statue of Galileo on the grounds of the Vatican had been suspended.

Impact on modern science

Galileo showing the Doge of Venice how to use
the telescope (fresco by Giuseppe Bertini, 1858)

According to Stephen Hawking, Galileo probably bears more of the responsibility for the birth of modern science than anybody else, and Albert Einstein called him the father of modern science.

Galileo's astronomical discoveries and investigations into the Copernican theory have led to a lasting legacy which includes the categorisation of the four large moons of Jupiter discovered by Galileo (Io, Europa, Ganymede and Callisto) as the Galilean moons. Other scientific endeavours and principles are named after Galileo including the Galileo spacecraft.

Partly because the year 2009 was the fourth centenary of Galileo's first recorded astronomical observations with the telescope, the United Nations scheduled it to be the International Year of Astronomy.

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International Year of Astronomy

https://en.wikipedia.org/wiki/International_Year_of_Astronomy

The **International Year of Astronomy** (**IYA2009**) was a year-long celebration of astronomy that took place in 2009 to coincide with the 400th anniversary of the first recorded astronomical observations with a telescope by Galileo Galilei and the publication of Johannes

Kepler's *Astronomia nova* in the 17th century.[1] The Year was declared by the 62nd General Assembly of the United Nations.[2][3] A global scheme, laid out by the International Astronomical Union (IAU), was also endorsed by UNESCO, the UN body responsible for educational, scientific, and cultural matters.[4]

The IAU coordinated the International Year of Astronomy in 2009. This initiative was an opportunity for the citizens of Earth to gain a deeper insight into astronomy's role in enriching all human cultures. Moreover, served as a platform for informing the public about the latest astronomical discoveries while emphasizing the essential role of astronomy in science education. IYA2009 was sponsored by Celestron and Thales Alenia Space.

The IYA2009 logo

International Year of Astronomy commemorative coin

Significance of 1609

On 25 September 1608, Hans Lippershey, a spectacle-maker from Middelburg, traveled to The Hague, the then capital of the Netherlands, to demonstrate to the Dutch government a new device he was trying to patent: a telescope. Although Hans was not awarded the patent, Galileo heard of this story and decided to use the "Dutch perspective glass" and point it towards the heavens.

In 1609, Galileo Galilei first turned one of his telescopes to the night sky and made astounding discoveries that changed mankind's conception of the world: mountains and craters on the Moon, a plethora of stars invisible to the naked eye, and moons around Jupiter. Astronomical observatories around the world promised to reveal how planets and stars are formed, how galaxies assemble and evolve, and what the structure and shape of our Universe actually are. In the same year, Johannes Kepler published his work *Astronomia nova*, in which he described the fundamental laws of planetary motions.

However Galileo was not the first to observe the Moon through a telescope and make a drawing of it. Thomas Harriot observed and detailed the Moon some months before Galileo. "It's all about publicity. Galileo was extremely good at irritating people and also using creative writing to communicate what he was learning in a way that made people think," says Pamela Gay in an interview with Skepticality in 2009.

Intended purpose

U.S. President Barack Obama views a double star in the constellation Lyra through an 8" Schmidt-Cassegrain telescope during the 2009 White House Astronomy Night.

Vision

The vision of IYA2009 was to help people rediscover their place in the Universe through the sky, and thereby engage a personal sense of wonder and discovery. IYA2009 activities took place locally, nationally, regionally and internationally. National Nodes were formed in each country to prepare activities for 2009. These nodes established collaborations between professional and amateur astronomers, science centres and science communicators. More than 100 countries were involved, and well over 140 participated eventually. To help coordinate this huge global programme and to provide an important resource for the participating countries, the IAU established a central Secretariat and the IYA2009 website as the principal IYA2009 resource for public, professionals and media alike.

Aims

Astronomy, perhaps the oldest science in history, has played an important role in most, if not all, cultures over the ages. The International Year of Astronomy 2009 (IYA2009) was intended to be a global celebration of astronomy and its contributions to society and culture, stimulating worldwide interest not only in astronomy, but in science in general, with a particular slant towards young people.

The IYA2009 marked the monumental leap forward that followed Galileo's first use of the telescope for astronomical observations, and portrays astronomy as a peaceful global scientific endeavour that unites amateur and professional astronomers in an international and multicultural family that works together to find answers to some of the most fundamental questions that humankind has ever asked. The aim of the Year was to stimulate worldwide interest in astronomy and science under the central theme "The Universe, Yours to Discover."

Several committees were formed to oversee the vast majority of IYA2009 activities ("sidewalk astronomy" events in planetariums and public observatories), which spun local, regional and national levels. These committees were collaborations between professional and amateur astronomers, science centres and science communicators. Individual countries were undertaking their own initiatives as well as assessing their own national needs, while the IAU acted as the event's coordinator and catalyst on a global scale. The IAU plan was to liaise with, and involve, as many as possible of the ongoing outreach and education efforts throughout the world, including those organized by amateur astronomers.

Goals

The major goals of IYA2009 were to:

1. Increase scientific awareness;
2. Promote widespread access to new knowledge and observing experiences;

3. Empower astronomical communities in developing countries;
4. Support and improve formal and informal science education;
5. Provide a modern image of science and scientists;
6. Facilitate new networks and strengthen existing ones;
7. Improve the gender-balanced representation of scientists at all levels and promote greater involvement by underrepresented minorities in scientific and engineering careers;
8. Facilitate the preservation and protection of the world's cultural and natural heritage of dark skies in places such as urban oases, national parks and astronomical sites.

As part of the scheme, IYA2009 helped less-well-established organizations from the developing world to become involved with larger organizations and deliver their contributions, linked via a huge global network. This initiative also aimed at reaching economically disadvantaged children across the globe and enhancing their understanding of the world.

The Secretariat

The central hub of the IAU activities for the IYA2009 was the IYA2009 Secretariat. This was established to coordinate activities during the planning, execution and evaluation of the Year. The Secretariat was based in the European Southern Observatory headquarters in the town of Garching near Munich, Germany. The Secretariat was to liaise continuously with the National Nodes, Task Groups, Partners and Organizational Associates, the media and the general public to ensure the progress of the IYA2009 at all levels. The Secretariat and the website were the major coordination and resource centers for all the participating countries, but particularly for those developing countries that lack the national resources to mount major events alone.

Cornerstone projects

The International Year of Astronomy 2009 was supported by eleven Cornerstone projects. These are global programs of activities centered on specific themes and are some of the projects that helped to achieve IYA2009's main goals; whether it is the support and promotion of women in astronomy, the preservation of dark-sky sites around the world or educating and explaining the workings of the Universe to millions, the eleven Cornerstones were the key elements in the success of IYA2009.

100 Hours of Astronomy

100 Hours of Astronomy (**100HA**) is a worldwide astronomy event that ran 2–5 April 2009 and was part of the scheduled global activities of the International Year of Astronomy 2009. The main goal of 100HA was to have as many people throughout the world as possible looking through a telescope just as Galileo did for the first time 400 years ago. The event included special webcasts, students and teachers activities, a schedule of

events at science centers, planetariums and science museums as well as 24 hours of sidewalk astronomy, which allowed the opportunity for public observing sessions to as many people as possible.

Galileoscope

The **Galileoscope**[12] was a worldwide astronomy event that ran 2–5 April 2009, where the program was to share a personal experience of practical astronomical observations with as many people as possible across the world. It was collaborating with the US IYA2009 National Node to develop a simple, accessible, easy-to-assemble and easy-to-use telescope that can be distributed by the millions. In theory, every participant in an IYA2009 event should be able to take home one of these little telescopes, enabling them to observe with an instrument similar to Galileo's one.

Cosmic Diary

The **Cosmic Diary**, a worldwide astronomy event that ran 2–5 April, was not about the science of astronomy, but about what it is like to be an astronomer. Professionals were to blog in texts and images about their life, families, friends, hobbies and interests, as well as their work, latest research findings and the challenges they face. The bloggers represented a vibrant cross-section of working astronomers from all around the world. They wrote in many different languages, from five continents. They have also written feature article "explanations" about their specialist fields, which were highlighted in the website. NASA, ESA and ESO all had sub-blogs as part of the Cosmic Diary Cornerstone.

The Portal to the Universe

The Portal to the Universe (**PTTU**) was a worldwide astronomy event that ran 2–5 April 2009, to provide a global, one-stop portal for online astronomy contents, serving as an index, aggregator and a social-networking site for astronomy content providers, laypeople, press, educators, decision-makers and scientists. PTTU was to feature news, image, event and video aggregation; a comprehensive directory of observatories, facilities, astronomical societies, amateur astronomy societies, space artists, science communication universities; and Web 2.0 collaborative tools, such as the ranking of different services according to popularity, to promote interaction within the astronomy multimedia community. In addition, a range of "widgets" (small applications) were to be developed to tap into existing "live data". Modern technology and the standardisation of metadata made it possible to tie all the suppliers of such information together with a single, semi-automatically updating portal.

She Is an Astronomer

Promoting gender equality and empowering women is one of the United Nations Millennium Development Goals. **She Is an Astronomer** was a worldwide astronomy event that ran 2–5 April 2009, to promote gender equality in astronomy (and science in general), tackling bias issues by

providing a web platform where information and links about gender balance and related resources are collected. The aim of the project was to provide neutral, informative and accessible information to female professional and amateur astronomers, students, and those who are interested in the gender equality problem in science. Providing this information was intended to help increase the interest of young girls in studying and pursuing a career in astronomy. Another objective of the project was to build and maintain an Internet-based, easy-to-handle forum and database, where people regardless of geographical location could read about the subject, ask questions and find answers. There was also to be the option to discuss astronomy-sector-specific problems, such as observing times and family duties.

Dark Skies Awareness

Dark Skies Awareness was a worldwide astronomy event that ran from 2 to 5 April 2009. The IAU collaborated with the U.S. National Optical Astronomy Observatory (NOAO), representatives of the International Dark-Sky Association (IDA), the Starlight Initiative, and other national and international partners in dark-sky and environmental education on several related themes. The focus was on three main citizen-scientist programs to measure local levels of light pollution. These programs were to take the form of "star hunts" or "star counts", providing people with a fun and direct way to acquire heightened awareness about light pollution through firsthand observations of the night sky. Together, the three programs were to cover the entire International Year of Astronomy 2009, namely GLOBE at Night (in March), the Great World Wide Star Count (in October) and How Many Stars (January, February, April through September, November and December).

UNESCO and the IAU were working together to implement a research and education collaboration as part of UNESCO's thematic initiative, **Astronomy and World Heritage** as a worldwide astronomy event that also ran 2–5 April 2009. The main objective was to establish a link between science and culture on the basis of research aimed at acknowledging the cultural and scientific values of properties connected with astronomy. This programme provides an opportunity to identify properties related to astronomy located around the world, to preserve their memory and save them from progressive deterioration. Support from the international community is needed to implement this activity and to promote the recognition of astronomical knowledge through the nomination of sites that celebrate important achievements in science.

Galileo Teacher Training Program

The **Galileo Teacher Training Program** (**GTTP**): the International Year of Astronomy 2009 provided an opportunity to engage the formal education community in the excitement of astronomical discovery as a vehicle for improving the teaching of science in classrooms around the world. To help

training teachers in effective astronomy communication and to sustain the legacy of IYA2009, the IAU – in collaboration with the National Nodes and leaders in the field such as the Global Hands-On Universe project, the US National Optical Astronomy Observatory and the Astronomical Society of the Pacific – embarked on a unique global effort to empower teachers by developing the Galileo Teacher Training Program (GTTP).

The GTTP goal was to create a worldwide network of certified "Galileo Ambassadors" by 2012. These Ambassadors were to train "Galileo Master Teachers" in the effective use and transfer of astronomy education tools and resources into classroom science curricula. The Galileo Teachers were to be equipped to train other teachers in these methodologies, leveraging the work begun during IYA2009 in classrooms everywhere. Through workshops, online training tools and basic education kits, the products and techniques developed by this program could be adapted to reach locations with few resources of their own, as well as computer-connected areas that could take advantage of access to robotic optical and radio telescopes, webcams, astronomy exercises, cross-disciplinary resources, image processing and digital universes (web and desktop planetariums). Among GTTP partners, the Global Hands-On Universe project was a leader.

Universe Awareness

Universe Awareness (**UNAWE**)[20] was a worldwide astronomy event that also ran during 2–5 April 2009, as an international program to introduce very young children in under-privileged environments to the scale and beauty of the Universe. Universe Awareness noted the multicultural origins of modern astronomy in an effort to broaden children's minds, awaken their curiosity in science and stimulate global citizenship and tolerance. Using the sky and children's natural fascination with it as common ground, UNAWE was to create an international awareness of their place in the Universe and their place on Earth.

From Earth to the Universe

From Earth to the Universe Movie Poster

Visit these Web Links to watch the Movie

[01] *"From Earthe to the Universe - Planetarium Show"*

https://www.youtube.com/watch?v=SR5ofv2l35Q [32:08]

A planetarium is a theatre built primarily for presenting educational and entertaining shows about astronomy and the night sky, or for training in celestial navigation.

[02] *From Earth to the Universe" ESO Planetarium Film"*

https://www.youtube.com/watch?v=dDOL3N2FYGQ [31:40]

A planetarium film from ESO and Theofanis N. Matsopoulos. Viewing this VR180 video with a headset will give you the planetarium experience from the comfort of your own home.

[03] *The planetarium show "From Earth to the Universe" v2*

https://www.youtube.com/watch?v=WZp2M9kGKlc [31:40]

The Cornerstone project **From Earth to the Universe** (**FETTU**) is a worldwide public science event that began in June 2008, and still ongoing through 2011. This project has endeavored to bring astronomy images and their science to a wider audience in non-traditional informal learning venues. In placing these astronomy exhibitions in public parks, metro stations, art centers, hospitals, shopping malls and other accessible locations, it has been hoped that individuals who might normally ignore or even dislike astronomy, or science in general, will be engaged.

Developing Astronomy Globally

The **Developing Astronomy Globally** was a worldwide astronomy event that ran during 2–5 April 2009, as a Cornerstone project to acknowledge that astronomy needs to be developed in three key areas: professionally (universities and research); publicly (communication, media, and amateur groups) and educationally (schools and informal education structures). The focus was to be on regions that do not already have strong astronomical communities. The implementation was to be centred on training, development and networking in each of these three key areas.

This Cornerstone was using the momentum of IYA2009 to help establish and enhance regional structures and networks that work on the development of astronomy around the world. These networks were to support the current and future development work of the IAU and other programmes, plus ensure that developing regions could benefit from

IYA2009 and the work of the other Cornerstone projects. It was to also address the question of the contribution of astronomy to development.

Galilean Nights

The **Galilean Nights** was a worldwide astronomy event that also ran 2–5 April 2009, as a project to involve both amateur and professional astronomers around the globe, taking to the streets their telescopes and pointing them as Galileo did 400 years ago. The sources of interest were Jupiter and its moons, the Sun, the Moon and many others celestial marvels. The event was scheduled to take place on 22–24 October 2009. Astronomers were to share their knowledge and enthusiasm for space by encouraging as many people as possible to look through a telescope at planetary neighbours.

Galileo before the Holy Office, a 19th-century painting.

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